Progress Report: The Role of Attention in Visual Processing

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During the first six months of the grant, work has proceeded in three areas.

1. I have characterized the attentional dependencies of an aftereffect that is a three-dimensional analog of the motion aftereffect. This is the first reported instance in which attention modulates the strength of a visual aftereffect and supports the basic idea underlying the grant: that one can use adaptation phenomena to relate the action of attention to specific visual mechanisms.

If one views an object on a monitor whose direction of rotation is specified through perspective, then a subsequent object presented without perspective, whose direction of rotation is normally ambiguous, will be seen to rotate in the opposite direction. Adapting to the unambiguous stimulus has desensitized mechanisms specific for a particular direction of rotation in depth. I now have data indicating that the extent to which this adaptation process occurs depends on the extent to which the adapting stimulus is attended. This result suggests that the mechanisms that are being adapted in these experiments are also capable of being attentionally influenced.

I have demonstrated this result in four experiments. In one of these, the subject sees a large and small square, one centered within the other. The large square rotates about its vertical axis in one direction, the small square about its vertical axis in the other direction. The direction of rotation of both adaptation stimuli are

unambiguous because they are specified by perspective. Occasionally, the corners of either the large or small square are perturbed and subjects are instructed to detect those perturbations. By changing whether subjects were instructed to detect perturbations in the large or small square, I controlled whether the subject attended to the large or small square during the adaptation phase. After the large and small square are displayed for 33 seconds, a single test square, which is the same size as the large adapting square, is presented. The square is presented without perspective and its direction of rotation is therefore ambiguous, sometimes seen as clockwise, sometimes counter-clockwise. Subjects are asked to assign a direction. The results show that if during the adaptation phase, subjects detected perturbations in the large square, the test square is seen to rotate opposite the direction of the large adapting square. If during the adaptation phase, subjects detected perturbations in the small square, the test square is seen to rotate opposite the direction of the small adapting square. The ability of either adapting square to desensitize mechanisms that analyze rotation in depth seems to be dependent on whether that adapting square is attended. Other results in the literature suggest that this adaptation effect may reflect the stage at which information from the various mechanisms that extract depth, stereopsis, perspective, etc. are integrated into a single representation. The present results suggest that attention affects this integration process.

Other experiments I have completed show that the mechanisms that are being attentionally modulated are retinal/location specific. The key result here is that the extent of the attentional modulation - the change in the aftereffect when one attends to one or the other adapting stimulus - depends on the degree to which each adapting component transfers to the test stimulus. For example, in one experiment, the adaptation display consisted of two squares of the same size, one in the left visual field

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and one in the right visual field, rotating in opposing directions. The test stimulus was identical to the left field adapting stimulus. With this display, the change in the aftereffect from switching attention from the left to the right adapting stimulus was less marked than in the previous experiment. A separate experiment demonstrated that the transfer of the aftereffect from the right field adapting stimulus to the left field test stimulus in this experiment was much less than the transfer of the small adapting square to the large test square in the previous configuration.

I have developed a quantitative model to account for these results which should be applicable to any aftereffect involving a binary response. The model suggests that attention modulates the strength of a mechanism's response in a multiplicative fashion.

The results of five experiments and the model have been written up and submitted for publication.

2. I have begun experimentation with a second aftereffect involving specification of the direction of motion of a stimulus. If subjects view a field of random dots moving at an orientation of 60 degrees, then a subsequent field moving at 90 degrees will be seen to move at greater than 90 degrees. This effect is essentially a motion analog of the tilt aftereffect. So far, this aftereffect appears less amenable to attentional influences.

3. Many of the experiments proposed in the grant use a particular piece of apparatus for presenting gratings and other standard psychophysical stimuli. That equipment has been received and interfaced to the lab computer. Most of the relevant

software has been written. There are still a few problems that need to be resolved, but experimentation should start within the next month or two.